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INVENTORY OF FOREST AND RANGELAND AND DETECTION OF FOREST STRESS

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16. Abstract

Eucalyptus tree stands killed by low temperatures in December 1972 were outlined by image enhancement of two separate dates of ERTS images (January 22, 1973 - I.D. 1183-18175 and April 22, 1973 - I.D. 1273-18183). Tree stands larger than 500 meters in size were detected very accurately.

In Colorado, range and grassland communities were analyzed by visual interpretation of color composite scene I.D. 1028-17135. We found that mixtures of plant litter, amount and kind of bare soil, and plant foliage cover made classification of grasslands very difficult.

Changes in forest land use were detected on areas as small as 5 acres when ERTS color composite scene 1264-15445 (April 13, 1973) was compared with 1966 ASCS index mosaics (scale 1:60,000). Verification of the changes were made from RB-57 underflight CIR transparencies (scale 1:120,000).

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Figure 2. Technical Report Standard Title Page

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Black Hills Test Site (Forest Stress) 226A

Coinvestigator: F. P. Weber

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. The lack of financial support for processing Mission 56 Multispectral Scanner data gathered May 1972 as ERTS-1 aircraft data has been identified as a problem in previous reports. The problem is still unresolved. New information from the Environmental Research Institute of Michigan indicates that M-56 data has two unique features which could be significant if the data were analyzed.

Mission 56 was the first to utilize a new feature of the M-7 scanner, the addition of a very narrow band (.71 to .73 μm) from a new access port which when ratioed to a green channel and also to a thermal band should be very good for identifying green (foliage color) beetle-attacked ponderosa pine. Second, Mission 56 also utilized a new feature of the M-7 scanner where the entire scanner was tilted at a 30° forward-looking angle. There is very good reason now to believe that the tilted scanner data gathered at low sun angles in the morning might be very good for stress detections, especially in detecting foliage moisture content differences. These two unique features of the M-56 data collection seem to us sufficient reason to justify additional funds from the ERTS program to process the MSS data at the University of Michigan.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Biophysical data were collected via the ERTS-1 Data Collection Platforms at the Black Hills site from September 12, 1973, through November 16, 1973. Data collection was in support of a C-130 aircraft mission (Mx247) on September 17, an RB-57 aircraft mission and a scheduled Skylab Earth Resource mission on September 18, and ERTS-1 passes on September 20/21, October 8/9, and October 26/27.

Results of the analyses of the biophysical data (Table 1) show that September 17 and 18 (Days 260 and 261) were clear days for the Skylab

Table 1. DCS/DCP Data Analysis for Black Hills Test Site 226A

Date	Time	Air Temp (C)	Incident Energy (MWatt/Cm^2)	Scene Radiance (MWatt/Ster·Cm^2) (MSS-4) I	H	A	(MSS-5) I	H	A	(MSS-6) I	H	A	(MSS-7) I	H	A	Weather
73260	17002	17.6	67.3	23.77	.23	.02	3.35	.11	.13	3.27	.32	.34	7.04	1.00	.80	Clear D
73261	17030	23.9	72.5	26.22	.19	.03	3.76	.10	.11	3.82	.32	.32	8.35	1.00	.76	Clear D
73263	17110	13.9	35.4	12.59	.11	.02	1.86	.04	.06	1.79	.15	.18	3.92	0.48	.40	Cloudy I
73281	17123	13.2	39.7	13.98	.13	---	2.17	.06	---	2.07	.19	---	4.53	0.59	---	Cloudy I

I = Irradiance (MWatt/Cm^2)

H = Healthy Pine Radiance (MWatt/Ster·Cm^2)

A = Dead Pine Radiance (MWatt/Ster·Cm^2)

pass and for the aircraft support mission. However, on September 20 and October 8 (ERTS-1 Days 263 and 281) the study site was covered by clouds at the time the MSS images were taken. Further analysis revealed that low incident readings were probably the result of a general overcast condition in the northern Black Hills rather than the result of scattered clouds.

2. A computer program has been completed for cross conversion of ecosite locations from either standard map coordinates to UTM coordinates or in reverse. Since most of our ecosite mapping and photo interpretation estimates are based on standard map coordinates it is now a simple process to convert locations to UTM coordinates which are sometimes preferred in CCT analyses.

3. Photo interpretation is in progress on the 1:32,000 color infrared resource photos taken in August 1973. Initial effort is concentrated in two heavily infested areas for correlation of 1973 interpretation results with those of 1972. It is obvious that the number of infestations and the total number of dead trees has greatly increased from 1972 to 1973.

Color prints were made from the original color IR photographs taken this August for ERTS ground truth; the prints are being used by the Black Hills National Forest in selecting timber sale areas for salvage cutting. To date, over 63,000 dead and infested trees have been removed in the salvage operation from one management district alone. The foresters report the photos to be of great help in locating infested trees.

4. Color composites have been made on the I^2S image combiner for scenes 1334-17124 (June 22, 1973) and 1352-17123 (July 10, 1973). A great deal of time was spent in achieving satisfactory registration of MSS band 4, 5, and 7 and to attain a color negative with good color balance. The color negatives are being used to produce color transparencies of several scales. A scale of 1:250,000 is desired for scanning on the microdensitometer while portions of each frame will be enlarged to a scale of 1:55,000 for human photo interpretation.

Other color negative composites have been made on the I^2S of 70 mm Hasselblad images taken on board the C-130 from Missions 213 (September 1972) and 247 (September 1973). We have found it very useful to optimize the color composites for stress detection on the aircraft imagery and then use the same color balance (by channel) in setting up the color composite of an ERTS-1 image.

5. A composite ERTS image from two time periods was created of the Eucalyptus tree killing in the San Francisco Bay Area. MSS band 7 of ERTS image (1183-18175) obtained January 22, 1973, and prior to foliage

discoloration was superimposed on MSS bands 5 and 7 of an April 22, 1973, image (1273-18183) which was after Eucalyptus foliage turned yellow. The two-date image combination discriminated dead stands of trees larger than 500 meters from all other objects on the image. A blue filter was used on the MSS 7 January image and a green filter and red filter used on the MSS 5 and 7 April image, respectively

WORK PLANNED FOR THE NEXT REPORTING PERIOD:

1. A program will be completed for plotting the results of the DCP-spectrometer radiance analyses. The plotting routine will be used for the final display of biophysical data collected in the Black Hills for correlation with ERTS-1 MSS scene radiance analyses.

2. Photo interpretation of the August 1973 resource photography will be completed, and will be correlated with the results of the 1972 photo interpretation.

3. We plan to select a subcontractor for analyzing two scenes from each of the three main test site areas. Check areas have been established within the Black Hills and Atlanta test sites and within five blocks in Colorado.

SIGNIFICANT RESULTS: None

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: None

STANDING ORDER FORM CHANGES: None

ERTS-1 IMAGE DESCRIPTOR FORMS: Three (3)

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Atlanta Test Site (Forest Inventory) 226B

Coinvestigator: Robert C. Aldrich

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Some color composites for images required in our analysis have not been received.

Scene Number	Date Ordered
1209-15385	June 25, 1973
1265-15503	May 25, 1973
1299-15385	July 19, 1973
1336-15441	Sept 25, 1973

2. Although we have greatly improved our combined color composites, made from the I^{2}S additive color viewer, we still have some registration problems within the scene that must be overcome. We feel that the problem is caused by variations in film flatness which will require a vacuum back for the film holder.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Two-hundred and thirty 1-acre plots were transferred from 1:20,000 scale Department of Agriculture photographs (1966) to 1:120,000 scale high altitude color infrared photographs taken on June 5, 1972. These plots represent the forest inventory sample established by the nationwide Forest Survey[1/] for five counties in North Central Georgia. Changes in land use and the occurrence of disturbances on these plots since 1966 are being monitored (1) on 1:120,000 high altitude color infrared (CIR) photographs taken in June and October 1972, (2) on high altitude photography requested for January 1974, and (3) on ERTS imagery

1/ A Branch of the Division of Forest Economics and Marketing Research Forest Service, U. S. Department of Agriculture.

for October 15, 1972 (1084-15440), April 13, 1973 (1264-15445), and June 24, 1973 (1336-15445). Additional ERTS imagery will be used as acquired.

2. Using a Zoom Transfer Scope (ZTS) with special Forest Service modifications, the photo index sheets of 1966 Department of Agriculture photography for Carroll County, Georgia were examined simultaneously with a color composite of ERTS scene 1264-15445 (April 13, 1973). Changes in land use from forest to nonforest and from nonforest to forest and all other disturbances to the forest were noted and circled directly on the photo index sheets. A 0.5 X lens attached to the 1.0 X map objective reduced the scale of the 1:63,360 photo index sheets to come within the scale change range of the ZTS. A foot switch blinker attached to the index sheet illuminators made it possible to register the ERTS data with the index sheets.

3. Changes in the forest environment detected on ERTS were checked in June 1972 high altitude CIR using the ZTS once again. Information was recorded in three categories: (1) changes or disturbances correctly identified, (2) changes or disturbances incorrectly identified (commission errors), and (3) changes or disturbances not identified (ommission errors). Changes not identified on ERTS were noted on the index sheets and then re-examined on the ERTS color composite. A record was made of the changes or disturbances that could be detected as well as those that could not be detected. For each area the following information was recorded:

a. The type of disturbance.

b. The land use trend indicated by the change.

c. The area in one of six classes.

   1. Less than 5 acres
   2. 5 - 25 acres
   3. 26 - 50 acres
   4. 51 - 500 acres
   5. 501 - 5000 acres
   6. over 5000 acres

d. Disturbances detected on initial ERTS examination.

e. Disturbances detected on 1:120,000 CIR film.

f. Disturbances detected on ERTS on second examination.

4. There were 210 genuine forest disturbances detected on the 1:120,000 CIR photographs. Of these 85 (or 40 percent) were detected originally on ERTS scene 1264-15445. Of the total number detected on CIR photography, 181 (or 86 percent) could be detected on ERTS by careful re-examination. The number of disturbances by category and size class are shown in Table 1. Also shown is the number and percentage of detectable disturbances by size class. A more complete analysis of the data will be included in the Type II Progress Report for the period July 1, 1973, to December 31, 1973.

5. During this reporting period we produced our first computerized, land use map for one 10,000-acre (3984-hectare) area using ERTS CCT for Scene 1084-15440. The overall accuracies of the stratification procedure are yet to be determined, however, the classifications in general look very good. Percentages of land in each strata were found as a by-product of the procedure. Land use was divided into nine classes - 5 forest classes, and 4 nonforest classes. The classification program between pine and hardwood typed very well but some mistyping occurred mainly for pixels lying on type boundaries. Unfortunately, the largest homogeneous areas are only 3 or 4 pixels in any direction and consequently, many pixels fall on type boundaries.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. We will continue to monitor Forest Survey plots on both high-altitude photography and ERTS imagery to determine the feasibility of ERTS and permanent plots for measuring changes in forest area and for detecting disturbances.

2. Land-use changes and disturbances occurring in Carroll County, Georgia, during the seven-year period between February 1966 and June 1972 will be fully analyzed by classification and size to determine the likelihood of detection on ERTS.

3. A land-use classification test will be conducted using a multi-seasonal approach to classification. Thirty randomly selected sample points in each of eight forest and nonforest classes will be examined and classified by three interpreters. In the first phase of the test, interpreters will use a combination of ERTS color composites for scenes 1084-15440 (October 15, 1972) and 1264-15445 (April 13, 1973). In a second phase, ERTS color composites for scenes 1264-15445 and 1336-15441 (June 24, 1973) will be interpreted.

4. Within the next reporting period we hope to have numerical assessments of mapping accuracies for 4 different computer classification

TABLE 1. DISTRIBUTION OF FOREST DISTURBANCES BY TYPE AND AREA CLASSES AND THE NUMBER AND PERCENTAGE OF ALL DISTURBANCES DETECTABLE ON ERTS

DISTURBANCE	AREA CLASS (ACRES)						
	Less than 5	5-25	26-50	51-500	501-5000	Over 5000	Total
			Number of Disturbances				
Timber Cutting	5	10	8	13	7	2	45
Land Clearing							
Forest to Agriculture	52	35	5	9	0	0	101
Forest to Urban	7	12	3	0	2	0	24
Forest to Water	12	4	1	0	0	0	17
Regeneration	1	6	0	1	0	0	8
Other	1	10	1	3	0	0	15
Total	78	77	18	26	9	2	210
Number detectable	62	67	16	26	9	1	181
Percent detectable	80	87	89	100	100	50	86

methods: (1) no clustering - typing of individual pixels according to means of land-use prototypes, (2) clustering using "slicing" of the 4-dimensional data distribution, (3) clustering using distances between adjacent pixels, and (4) a quick clustering method based upon correlations of radiance values.

We will also attempt to extend the classification methods used to two other 10,000-acre (3984-hectare) blocks as well. Accuracies will be compared within and between blocks.

SIGNIFICANT RESULTS: None

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: None at present

STANDING ORDER FORM CHANGES: None at present

ERTS IMAGE DESCRIPTOR FORMS: A total of 3 submitted

DATA REQUEST FORMS: None at present

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Manitou Test Site (Rangeland Inventory) 226C

Coinvestigator: Richard S. Driscoll

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Retrospectively ordered bulk color composites of key ERTS scenes needed for our data analysis have not yet been received. These include six frames that include the total Manitou test site in each frame and ten scenes that include all or part of the Kremmling area as defined in Mr. Heller's letter to Mr. Provenzano on April 18, 1973. Consequently, our analysis of ERTS-1 data for range resources is still constrained to one scene obtained August 20, 1972 (Scene I. D. 1028-17135).

2. We have not yet received the Bausch & Lomb ZTS, ordered in July 1973, for use in sample point transfer from map sheets to ERTS-1 and supporting aircraft imagery.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. Description characteristics and descriptive keys for grassland units within the 226-C test site have been completed for aircraft support Missions 205 and 211. This includes information for the color and color infrared photographs at scales of approximately 1:50,000, 1:100,000, and 1:400,000. Two of four interpreters have completed the photo interpretation testing. We are not yet ready to summarize the results.

2. Two of five interpreters have completed photo interpretation testing for the designated forest types imaged in the support aircraft photography. We are not yet ready to summarize the results. The vegetation types (classes) were defined in our Type II--Number 1 Progress Report dated January 10, 1973.

3. A hierarchical ecosystem classification scheme, ECOCLASS, recently developed by the Forest Service and which is useful to natural resource managers, is being tested for applicability of ERTS-1 imagery for natural resources. The hierarchy established, which is in accordance with ecological principals and is in current use by natural resource managers, is as follows:

Category	Definition
V - Formation:	The most general class of vegetation characterized by general appearance: i.e., grassland, coniferous forest, deciduous forest, etc.
IV - Region:	Groups of community systems with similar appearance and climatic controls: i.e., Montana grasslands, temperate mesophytic (medium moisture requirements) coniferous forests, Montane grasslands, alpine grasslands.
III - Series:	A group of vegetation systems having common dominant climax species: i.e., ponderosa pine forests, lodgepole pine forests, fescue grasslands, wheatgrass grasslands.
II - Habitat Type:	The unit with relatively pure internal biotic and abiotic structure: i.e., ponderosa pine-Arizona fescue, thurber fescue-aspen fleabane. These are the elemental units of the plant community classification scheme upon which management is based. Frequently related to "climax" situations or situations in a high successional level "held" in a relatively stable state by proper management.
I - Community Type:	Systems that appear relatively stable under management and may be frequently equivalent to the habitat type. Usually the biotic components are dissimilar, but abiotic components analogous to habitat type.

Visual interpretations of our one usable ERTS-1 color composite, I. D. 1028-17135, has defined the following limits of interpretation by categories. Unfortunately we cannot report statistics because we were forced to change from planned supervised to unsupervised interpretation due to radiometric and positional accuracy errors previously reported.

a. Interpretations for Categories IV and V, Region and Formation, are clearly definitive using ERTS only data.

b. Interpretations to Category III, Series, is not clearly definitive unless a high scene contrast exists between the classes of interest. For example, dense hydrophytic meadows, a Series in which the plant species are primarily sedges (Carex sp.) and rushes (Juncus spp.), differentiate from the drier mesophytic grasslands. However, Series within

the mesophytic grasslands cannot be consistently differentiated. Regarding the forest classes, consistent and acceptable differentiation at the Series level does not seem probable except for one forest Series (Aspen), the only deciduous forest Series within the test site.

c. Acceptable interpretations to Category II, Habitat Type, cannot be done by standard photo interpretation procedures using ERTS-1 only data.

4. Interpretations of grassland Series is confounded by the amount of plant foliage cover, the amount of litter on the ground, and the amount and kind of bare soil in the scene. These factors all affect color in the ERTS-1 color composite. For example, areas color coded to gray purplish red by the ISCC-NBS color standards have plant foliage cover ranging from 25 to 55 percent. Within this group, there are different grassland Series that were identified on the ground and in aircraft support photography. Likewise, two grasslands with similar vegetation structure but different soil surface conditions are different colors in the ERTS-1 combined color composite. We need to develop ways to circumvent this interpretation problem; it may be resolved with seasonal ERTS-1 color imagery which is on order.

5. Initial investigations have begun for image enhancement of selected vegetation and land-use classes in 226-C ERTS-1 scenes using the I^2S system in Berkeley. Scenes I. D. 1388-17134 and 1334-17142 were used to test a photographic procedure described in Type I Progress Report--Number 5 (Aldrich). Initial negatives and transparencies made by this technique are sharper than if photographed directly from the view screen. Exposure densities and colors are good. A procedure is now being developed that allows each color composite registered on the I^2S to have identical gray-scale presentation. This should insure uniform and repeatable color-band balance between sequential scenes and provide the assumption that color changes between scenes are real in relation to temporal vegetation changes and are not oeprator biased.

6. Digital analyses of the ERTS-1 bulk CCT's of Scene I. D. 1028-17135 have been delayed due to machine language changes at the Colorado State University CDC-6400, the unit we are using for computer analysis of the Manitou data.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. Complete photo interpretation testing for all vegetation classes using Mission 205 and 211 ERTS-1 support aircraft photography.

2. Resume bulk CCT analyses of Scene I. D. 1028-17135 as quickly as the programs can be adjusted to the change in maching language for the CDC-6400.

3. Initiate MDT point sampling for plant community and land-use classes using ERTS and ERAP imagery. This was delayed during the last reporting period due to preparations required for the ERTS PI Panel Review.

4. Continue image enhancement investigations of selected ERTS scenes of the Manitou and Kremmling areas. This will be done with the I^2S system in Berkeley.

SIGNIFICANT RESULTS:

The following significant result has been identified through visual interpretation of ERTS-1 bulk color composite Scene I. I. 1028-17135:

The amount of live plant foliage cover and plant litter, and the amount and kind of bare soil surface seriously confounds interpretation of single ERTS-1 color composites for grassland and plant communities in the central Colorado mountainous region. For example, some grassland communities classified at the Series hierarchical level will show widely varying color codes identified by the ISCC-NBS color standards. On the other hand, the same ISCC-NBS color code can represent more than one Series level grassland community. Color code 262, for example, represents members of the Mountain Bunchgrass, Shortgrass, and Basin Meadow community Series. The community Series is defined as a vegetation system having common dominant climax species: i.e., fescue grasslands, Danthonia grasslands, ponderosa pine forests, lodgepole pine forests. This problem may be resolved by interpretation of seasonal ERTS-1 color imagery.

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGE: None at present.

STANDING ORDER FORM CHANGE: None at present.

ERTS IMAGE DESCRIPTOR FORMS: 39 submitted, 5 to be submitted.

DATA REQUEST FORM CHANGES: None. Please send a pad of Data Request Forms.